Locally produced probiotic yoghurt for better nutrition and increased incomes in Uganda

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Summary

In this thesis we describe how we can increase health and wealth for people living in resource poor areas by enabling them to start a business in locally produced probiotic yoghurt.

We specifically focussed on Uganda, where farmland per capita is steeply decreasing as in many developing countries. Hence, the stimulation of non-farm rural incomes for example through cottage industry businesses, is essential as a driver for sustained economic growth. In terms of health, many low-income households in Uganda face poor sanitation and hygiene, cramped households and low availability or affordability of health care. In addition, the tropical climate causes a relatively high pressure of bacterial infectious diseases. Therefore, the poor are at increased risk of reduced quality of life as a result of sickness, including aflatoxin-related diseases, microbial infections, diarrheal diseases, and other contagious diseases. Also, due to a lack of dietary fibre in the national diet and the relatively high incidence of the gastric bacteria *Helicobacter pylori*, the incidence of gastric pathology including ulcers is high in Uganda. In this thesis, we hypothesized that through stimulation of the local production of probiotic yoghurt we could address both the economic and the public health constraints simultaneously. We investigated the technical prerequisites for making a probiotic starter culture and a locally applicable yoghurt production process, ways of stimulating economic growth, and the best methods for knowledge transfer to local entrepreneurs. In addition, we worked on the demand side and developed strategies to create access to healthy and affordable probiotic products for low-income households. Subsequently, we studied the health impact on the consumers.

In order to enable the local production of probiotic yoghurt, a novel starter culture was developed containing the probiotic strain *Lactobacillus rhamnosus* yoba 2012 (LRY), and the adjuvant strain *Streptococcus thermophilus* C106. The bacteria were freeze-dried and packed in water-tight sachets in portions of 1 g. This starter culture is used in a two-step fermentation process for the production of 100 L fermented foods, using only basic equipment such as a pan, thermometer and a source of heat, for example woodfire. We developed course material and trained potential producers on the application of the technology and how to run a business. The freeze-dried starter culture in combination with a standardized production protocol ensure a controlled fermentation process. This leads to a standardized product that can be packed and commercialized, as it has a much longer shelf life and a higher guarantee of food safety compared to traditional home-made fermented foods in Africa.

Later on, we evaluated the results of our activities and concluded that in Uganda over 135 groups, cooperatives and individual entrepreneurs adopted the tailor-made starter culture and production protocol, implying that they successfully started, maintained and expanded a business of probiotic yoghurt production and sales. Financial analysis of the yoghurt businesses showed relative attractive profit margins. Hence, dissemination of this concept in Uganda among others, 1) created employment and income for the business owners and possibly their hired workers, 2) created a market for the milk of the farmers in the neighbourhoods, 3) reduced milk spoilage, as yoghurt has a longer shelf life then milk, and 4) created access to a healthy and affordable product for the consumers in the catchment area. The latter is evident from the fact that by the end of 2019, 40,000 L per week found its way to the (rural) market in Uganda. The intervention strongly stimulated

women and youth involvement (53% of business owners were women and 22% were youth <35 years of age) in the dairy value chain, an area that they are usually excluded from.

We evaluated the evidence for health benefits of probiotics on the prevention, management or reduction of gastric pathology by a review of the literature. Our review indicated that *L. rhamnosus* yoba 2012 might be able to attenuate the symptoms associated with gastric pathology through (i) competition for binding sites between *L. rhamnosus* yoba 2012 and *H. pylori*, (ii) attenuation of the host's *H. pylori*-induced apoptosis, inflammation responses and stimulation of angiogenesis, and (iii) production of anti-microbial substances such as lactic acid to inhibit the proliferation of *H. pylori*.

In addition, we studied the health effects of the locally produced probiotic yoghurt on frequently occurring infectious diseases among school going children in Southwest Uganda. Previously, we introduced a regional school feeding program in which the consumption of probiotic yoghurt was specifically stimulated among pre-primary school going children. Parents were sensitized about the health benefits, and subsequently ask to pay for the inclusion of this product in the school menu, thereby ensuring sustainability of the program. In South-Western Uganda, by the close of 2019, over 20,000 children between the age of 3-6 year consume probiotic yoghurt at school, as paid for by their parents.

Next, we chose ten schools to assess the health benefits of the probiotic yoghurt. A first study was conducted in which 584 children (3-6 years) who consumed the yoghurt on daily basis were followed for a school period of 11 weeks, and compared to 532 children who consumed the same amount of milk on daily basis in regards to several (health) parameters including common cold, skin diseases and absenteeism. Daily reports of nurses that visited the schools revealed a reduced incidence of common cold as well as skin disease such as tinea capitis. However, these findings lacked robustness, as the incidence of the diseases at baseline was significantly different between the two study arms. Therefore, a second double blind placebo-controlled study was conducted at one school in which 100 children (3-6 years) who consumed the yoghurt on daily basis were compared to 95 children who consumed a placebo dairy product for the same period. The same health parameters were checked as in the first study. This second study with a more robust study design confirmed a beneficial effect of probiotics on the incidence of skin disease as well as common cold.

In conclusion, a novel starter culture in combination with a low-tech production protocol and a tailor-made educational program, has proven to have the potential to provide work to women, men, and youth and to increase incomes in Uganda. The studies among young school-going children suggested that health benefits of probiotic yoghurt as found in other studies did also apply to the specific population that was targeted in the intervention. To conclusively prove the impact on health, further studies in which subjects who consume probiotic yoghurt are followed over a longer period of time are recommended. We have shown that the starter culture does not only ferment milk into probiotic yoghurt, but can also produce other fermented drinks on maize or millet basis. Inspired by the success in Uganda, in collaboration with other partners the locally produced probiotic yoghurt concept was introduced in other countries such as Tanzania, Kenya, Rwanda, Cote d'Ivore, Zimbabwe, Nepal and Indonesia.